RESEARCH HIGHLIGHT

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Technical Series 04-109

MAXIMUM PERFORMANCE TESTING OF POPULAR WATER-EFFICIENT TOILET MODELS

INTRODUCTION

Approximately one third of all indoor household water is used for toilet flushing when conventional 13-litre toilets are used. A desire to conserve water is leading many consumers to choose water efficient 6-litre toilet models when building or remodeling their homes. Many municipalities across Canada now offer financial rebates for 6-litre toilet retrofits while the province of Ontario and the city of Vancouver, mandate 6-litre toilets in all new construction.

Most 6-litre toilet models exceed customer performance expectations. However, recent research in Canada and the U.S. conclude that there are also certified and commercially available models that do not flush effectively, resulting in customer complaints and the need for double-flushing.

Currently, there is no convenient way for the customer to distinguish between good and marginal performers. In addition, this lack of information on toilet performance levels has served to create a negative perception regarding 6-litre technology in general, as opposed to identifying only the poor performers.

Another issue is the effect of flapper replacement on toilet flush performance. Flappers wear out and need to be replaced approximately every five years. The concern lies in the type of flapper used for replacement. Toilets using adjustable flappers may lose water savings if replaced with a standard flapper—the type typically found at most home supply stores.

RESEARCH PROGRAM

In 2003, CMHC organized a consortium of 22 water agencies from across Canada and the U.S. to test the effectiveness of low-flush toilets. The Maximum Performance Testing of Popular Toilet Models (MaP) program was led by the Canadian Water and Wastewater Association (CWWA) and sought to rank the toilet makes and models based on tested flush performance.

This work built on an earlier report, *Water Closet Performance Testing*, a National Association of Homebuilders Research Centre (NAHBRC) study undertaken in the U.S. but changed in three ways:

- a more realistic testing material was selected (soybean paste and toilet paper)
- each model was adjusted to flush with the required 6 litres[1]
- a minimum performance threshold was established (250 grams of solid waste)

During testing it was found that about a third of the models used more than 6 litres when adjusted to manufacturer's instructions. This correlates to an earlier CMHC field-study that found 6-litre toilet flush volumes ranging from 2.5 to 14 litres.

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METHODOLOGY

Flush performance:

A total of 80 different toilet model fixtures were tested. Of these 80 models, 44 toilet models were considered to meet all the requirements for the study. These were selected to include the top-selling models in the regions represented by the participating organizations. Two examples of each model were tested, purchased where possible "off-the-shelf" in a retail outlet. The remaining 36 toilet models tested were either prototypes (not currently available in the marketplace) provided directly by the manufacturer or single prototypes. The results from these models can be found within the report. All models tested used a variety of different flushing mechanisms and included both gravity-fed and pressure-assist models.

All toilets were initially set according to manufacturer's instructions and evaluated on actual flush volume. Where necessary toilets were recalibrated to flush with the required 6 litres.

Flush performance was assessed in two ways:

1. *Ability to flush solid material:* Sausage-shaped samples made of soybean paste were flushed with toilet paper to provide a realistic simulation demand on the toilet. The maximum weight of the test media that each model could completely flush, without double flushing, was recorded. The model was judged to be effective if it cleared a minimum of 250 grams of media[2].

2. *Ability to completely replace water in the bowl as part of a liquid-only flush:* A brine mixture was added to the bowl and the percentage of liquid exchanged was calculated by measuring the conductivity of the liquid in the bowl before and after the flush.

Flapper Replacement:

To test the effect of changing the flapper on flush volume, the original flapper was replaced, first with a standard flapper and then with each of the three most common models of "universal" (adjustable) flappers. In the case of the adjustable flappers, the testers attempted to adjust the flapper to achieve a flush volume of the required 6 litres.

For various reasons, replacement flappers could not be installed in every toilet model. For example, some toilets use proprietary flappers, such as the 3-inch (75 mm) flappers used in the Toto Drake, Ultramax, and Ultimate, the 2-inch (50 mm) disks used in the Mansfield Alto, and the proprietary flush valve seal in the American Standard Champion. Other models excluded from the test were pressure-assisted toilets, and toilets where the proper operation of the replacement flapper was prevented by interference from existing trim components.

RESULTS

Flush Volume "Out of the Box"

Approximately 30% of the models tested flushed with greater than 6 litres when removed from their factory carton, assembled on the test rig and adjusted in accordance with manufacturer's instructions. Only 13% flushed with 7 litres or more.

Solids Flushing Performance

Flush performance varied greatly, clearing from 100 to 900 + grams of solids. Of the 44 toilet models, 20 models flushed clearing less than 250 grams (Figure 1); 13 models flushed clearing between 250 grams and 500 grams (Figure 2); and 11 models flushed clearing in excess of 500g (Figure 3).

Impact of flapper replacement:

When the original flapper was replaced with a standard, non-adjustable buoyant flapper, 70% of the toilet models used more than the required maximum flush volume. The results are summarized in Table 1.

Liquid Flushing Performance

When the percentage of water exchanged on an all-liquid flush was measured, it was found that virtually all the models exchanged at least 98% of the water in the bowl on a single flush. Since those models that did not adequately clear solid material did well on this test, water exchange on a liquid-only flush does not appear to be a reliable indicator of the effectiveness of a toilet. Problems with water exchange are perhaps more likely to arise with a flush combining liquid and solids.

Even when adjustable flappers could be installed, it was not always possible to adjust them to flush with 6 litres/1.6 gallons. The Niagara[6] flapper could be adjusted to achieve the correct flush volume on the largest number of toilet models (79%). The Fluidmaster[6] flapper could be properly adjusted for 55% of toilet models, and the Frugal Flush[6] flapper for only 17% of toilet models tested.

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[2] J.B. Wyman, K.W. Heaton, A.P. Manning, and A.C.B. Wicks of the University Department of Medicine, Bristol Royal Infirmary, *Variability of colonic function in healthy subjects*, 1978.)

Figure 1: Models Clearing Less than 250 g of Solids

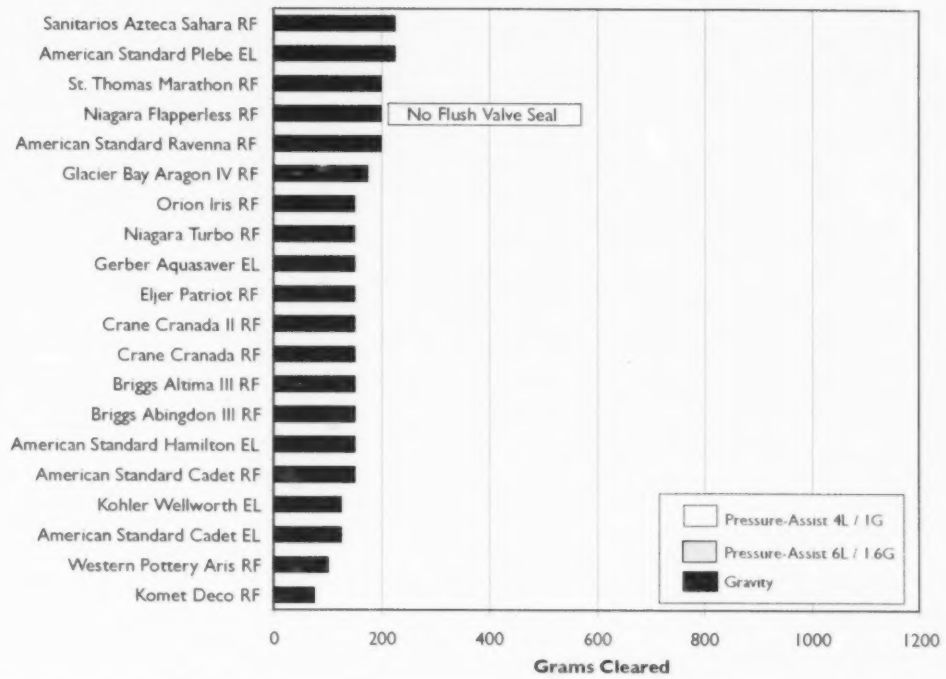

Figure 2: Models Clearing Between 250 g - 500 g of Solids

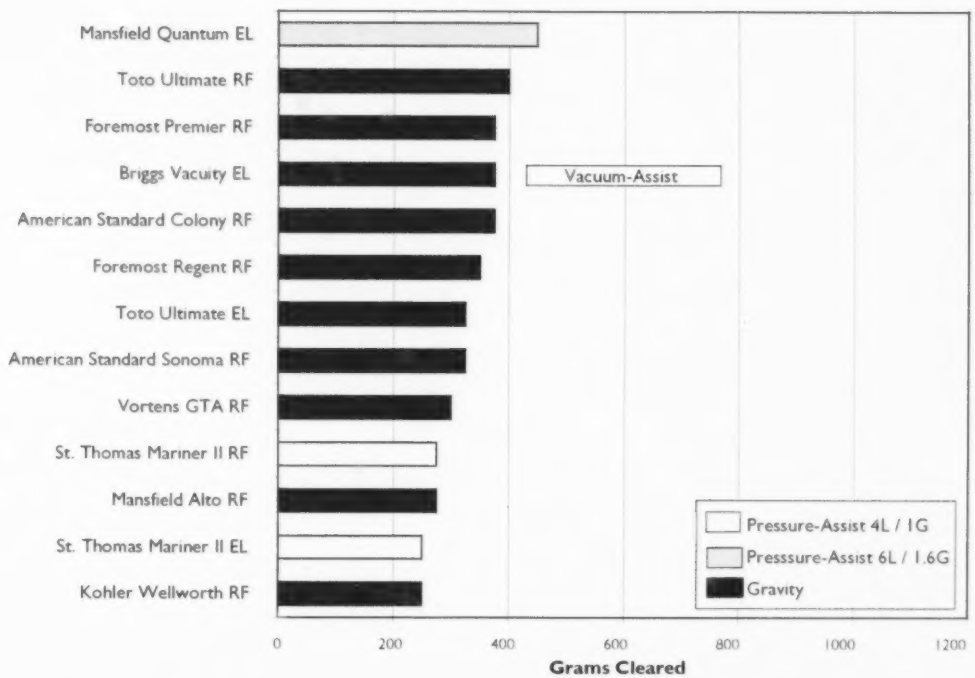

Figure 3: Models Clearing Greater than 500 g of Solids

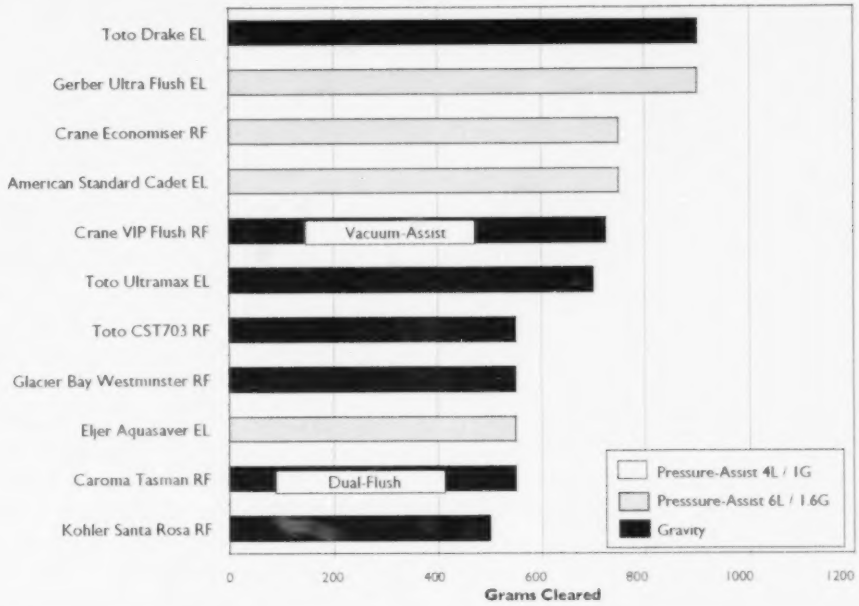

Table 1: Replacement with Standard Flapper

Manufacturer	Model	Flush Volume	
		Litres	Gallons
American Standard	Hamilton EL	4.9	1.29
Briggs (Proflo)	Vacuity EL	5.3	1.40
Niagara	Turbo RF	5.7	1.51
Crane	VIP Flush RF	6.0	1.59
Crane	Cranada II RF	6.1	1.61
Foremost	Regent RF	6.4	1.69
Briggs (Proflo)	Abingdon III RF	6.8	1.80
Briggs (Proflo)	Altima III RF	6.9	1.82
Foremost	Premier RF	7.3	1.93
Toto	CST703 RF	7.5	1.98
Mancesa	Charleston RF	8.0	2.11
Mancesa	Ste. Michelle RF	8.6	2.27
Glacier Bay	Westminster RF	9.5	2.51
American Standard	Sonoma RF	9.7	2.56
Eljer	Patriot RF	9.9	2.62
Kohler	Wellworth RF	9.9	2.62
Orion	Iris RF	9.9	2.62
Kohler	Wellworth EL	10.0	2.64
Crane	Cranada RF	11.0	2.91
Vortens	GTA RF	12.0	3.17
St. Thomas	Marathon RF	12.2	3.22
American Standard	Plebe EL	12.4	3.28
Western Pottery	Aris RF	12.7	3.36
Sanitarios Azteca (Lamosa)	Sahara RF	13.8	3.65
Gerber	Aquasaver EL	14.0	3.70
American Standard	Cadet RF	15.2	4.02
American Standard	Cadet (PA) EL	15.9	4.20

Implications for consumers and water providers

These results provide only a "snapshot" of the effectiveness of low-flush toilet models currently available:

1. The models selected do not represent all models currently on the market.
2. Since only two examples of each model were tested, the results may not represent performance of that model overall.
3. Models may have been modified since the testing was completed.

However, the study offers two clear conclusions:

Firstly, the results show that many low-flush toilets certified by standards bodies in Canada and the U.S. do not flush adequately when adjusted to the required 6-litre/1.6-gallon flush volume. For consumers to feel confident that it is worth investing in a low-flush toilet, they should be able to rely on certification as an indication that the model performs adequately at the required flush volume. Since the liquid exchange test does not appear to accurately indicate how well a toilet performs, it should not be relied on as an important part of the certification process. In contrast, the solid waste test developed for this study has been accepted as a good indicator of toilet performance and may offer a reliable testing method to be included as part of certification requirements. Following the methodology used in this study, soybean paste would be used to represent solid waste, and 250 grams would be adopted as a minimum threshold for adequate performance.

Secondly, the study confirmed that:

1. Many low-flush toilets use more water than indicated when set up according to the manufacturer's directions, and
2. Replacing the flapper is likely to affect the flush volume. Consumers should be encouraged to purchase models that can be easily set up to flush the appropriate volume. They should also consider models that are designed with a standard so that the flapper can be replaced with an equivalent model from a renovation centre. If choosing a model with a proprietary flapper, consumers should ensure that the proper replacement flapper is readily available. If consumers install an adjustable flapper, it may be difficult for them to identify the proper setting to maintain water savings and flush performance.

The desired water savings are more likely to be realized in water utility low-flush toilet rebate programs when toilets:

- can be easily set up to the correct volume
- are equipped with a standard, or proprietary flapper, and not an adjustable flapper
- perform adequately at the correct flush volume

PROJECT PARTNERS

Canada

- Canadian Water and Wastewater Association (CWWA) – LEAD AGENCY
- B.C. Capital Regional District, Victoria, British Columbia
- B.C. Buildings Corporation, Victoria, British Columbia
- Canada Mortgage and Housing Corporation
- Calgary, Alberta
- Edmonton, Alberta
- Greater Vancouver Regional District, British Columbia
- Halifax, Nova Scotia
- Hamilton, Ontario
- Montréal, Quebec
- Ottawa, Ontario
- Region of Durham, Ontario
- Region of Halton, Ontario
- Region of Peel, Ontario
- Region of Waterloo, Ontario
- Toronto, Ontario
- Winnipeg, Manitoba

U.S.A.

- California Urban Water Conservation Council, Sacramento, California
- East Bay Municipal Utility District, Oakland, California
- Los Angeles Department of Water and Power, Los Angeles, California
- Seattle Public Utilities, Seattle, Washington
- Tampa Bay Water, Clearwater, Florida

Research Report: Maximum Performance Testing of Popular Water-Efficient Toilet Models
Consultant: Veritec Consulting Inc.
Project Manager: Cate Soroczan

Housing Research at CMHC

Under Part IX of the *National Housing Act*, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

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